To: Donna Weiting, NMFS Office of Protected Resources
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Comments on the Navy EIA for the LFA/SURTASS program

My qualifications include a Ph.D. in marine seismology and ocean acoustics and a number of relevant publications on how whales use and produce calls (a detailed C.V. is available on the website www.whaleacoustics.com). I have worked on a number of Navy-funded ocean acoustics projects at Scripps Institution of Oceanography in California and at the University of Victoria in British Columbia.

My first encounter with the Navy Low Frequency Active (LFA) sound source occurred one evening in July 1994 while I was acoustically monitoring a group of sperm whales several hundred miles offshore the Oregon/Washington coast using a sonobuoy deployed from a NOAA research vessel. When the LFA source signal was first heard on the sonobuoy, I was forced to jump up and turn down the speaker, while people from all over that deck of the ship came running to find out what had made such a loud and unusual noise. Weeks later, after showing spectrograms of my recordings to a number of researchers in San Diego, I was able to confirm that the sounds had been transmitted from near San Diego during project Magellan, an acoustic propagation distance of nearly 1000 miles. Later that summer as project Magellan moved to the area off Monterey, the local scuba divers complained of hearing unusual noises and project Magellan ended as the news media began to investigate. My most recent encounter was last winter when I recorded strong long duration acoustic transmissions in the 3 kHz range coming from the direction of the Cory Chouest (the LFA source ship) some forty miles distant while we were acoustically studying blue whales off San Diego. My earlier recordings showed 220 to 280 Hz to be common frequencies, appropriate for long distance propagation, but apparently the LFA source is used at these much higher frequencies also.

One of my current research projects involves analyzing a six-year data set of near-continuous acoustic recordings from fifteen hydrophone sites ranging across the entire North Pacific. These data were acquired as part of the ATOC research program on ambient noise. In these data, the LFA signal is distinctly above background noise level at every one of the fifteen sites, including the Emperor Seamount chain. These observations confirm that there was nothing unusual about my first encounter with LFA in 1994. I do not mean to imply that every whale in the North Pacific will hear the source every time it is used, but many whales, potentially in every part of the North Pacific will hear it. Many factors complicate the determination of which whales would be expected to hear the LFA transmissions. For example, a whale near the surface when large waves are breaking will encounter a much higher local ambient noise and be less able to hear distant signals. As the LFA signals are best propagated in the deep sound channel, distant whales are more likely to hear the source if both the source ship and the whale are located above a sloping seafloor, which crosses the deep sound channel, allowing a better acoustic link.

The NMFS Call for Public Comment states the LFA sound source 'affects only a small area of the ocean at any one time'. I believe this statement is blatantly incorrect as can be documented with scientific data. The potential impact to whales distant from the LFA sound source (greater than 100 km) is unknown and can be argued to be negligible given the lower received sound levels at a distance, but stating the LFA sound source affects only a small area implies the sound is not heard by distant whales. Clearly, based upon my experiences recording LFA transmissions over the last 7 years, this is not the case. If whales hearing the LFA sound source at a relatively low sound level were the only problem with deployment of the LFA system I would not have bothered to write a comment, as whales arguably can adapt to this sound much as they have adapted to shipping noise.

I believe the critical issue for the Navy and NMFS should be the capability of this powerful sound source to cause resonance in the air cavities of a whale's head, if the animal is within a few tens of kilometers of the sound source. This issue first arose following the LFA sound source tests in the Mediterranean, which 'coincided' with beaked whale strandings, a most unusual event. Of course the stranded animals likely represent only the few who were not killed outright, sinking to the seafloor to remain undiscovered. There are no natural sound sources to compare to these military sonars and most of us who have studied and written about bubble resonance in whales, still did not anticipate the reality of what is likely to be happening.

Resonance, as a physical phenomena, takes many forms, most of which are not intuitive to the average observer. An example would be the collapse of the Tacoma Narrows suspension bridge due to a wind driven resonance. The acoustically driven resonance of an air bubble in water is a well-understood phenomena. The effects of having such an air bubble inside a whale's head rather than in open water affects only the details of the equations involved. In the case of a whale, nearly all the air from the lungs is forced into the nasal passages (baleen whales) or sinuses (odontocetes other than sperm whales) of the animal by the time the animal has reached a dive depth of about 90 meters. For a blue whale at 90 meters depth this volume may be 200 liters, while for a beaked whale at greater dive depths this volume may be as little as 0.5 liters, the volume continuously changing as the whale changes depth. For a given air volume there is a resonant frequency, measured in Hertz, at which a sound source will cause the bubble to expand and collapse dramatically. For certain species at certain depths there may be special forms of resonance, which apply given the shape of the air bubble and rigidity of the surrounding tissues. One example would be the Helmholtz Resonance in which air rushes back and forth between two cavities.

Most underwater acousticians would have considered the tactical sonar to be less likely than the LFA sonar to cause the bubble resonance phenomena due to the relatively short duration and high frequency sweep rates typical of tactical sonar transmissions when compared to LFA. The mathematical equations for calculating resonance indicate the air volume, the frequency, the frequency sweep rate and the duration of the sonar transmission are the key parameters. The surrounding membrane or bone stiffness, air chamber shape and number of air chambers will be secondary factors. The air volume in a whales head will be determined largely by the dive depth of the whale and its species, thus the resonance frequency is a continuum over a broad range of frequencies in a given whale as the whale dives. The necropsy results from the Bahamas animals provide the first solid evidence that this well understood phenomena of air bubble resonance is actually killing whales. It is an ominous indicator for the LFA sound source that tactical sonar appears to have ruptured the membranes in the heads of the animals stranded in the Bahamas.

It remains unclear what frequencies the LFA sonar will be used at, although from my recording experiences, it can be used at frequencies similar to tactical sonar (i.e., ~ 3 kHz). It also remains unclear what range of frequencies cause resonance in each species of whale and over what dive depths. The Bahamas evidence suggests a number of different whale species were affected. The theoretical calculations suggest that baleen whales would be expected to have much different resonance frequencies than beaked whales, yet both types were apparently affected in the Bahamas incident. This implies that resonance related injuries are not restricted to only a few species or to special or unusual situations.

The presence of a strong surface propagation duct in the Bahamas during the incident is not obviously related to an increased risk of resonance injury to whales, as I would have expected resonance related injuries to occur when whales were at depths below the surface propagation duct. The acoustic intensity would have been less intense below the duct than if no duct were present. Thus, it is not apparent that unusual propagation conditions in any way contributed to the Bahamas injuries and in fact it may prove to be just the opposite, where the unusual propagation conditions saved more whales from injury.

The Mediterranean stranding event combined with the Bahamas data, suggests that the LFA sound source can, and may have already, killed whales. I believe the use of LFA will continue to result in the stranding of dying animals, annoyance and potential injury to scuba divers and swimmers and the deaths of many animals which are likely to go undiscovered as these animals sink to the seafloor. I urge you to make approval of the EIS contingent on further studies of the air bubble resonance phenomena in whales, other animals, and humans.